Ultrafast Photoinduced Electron Transfer from Conjugated Polymers to Acceptors

High Performance Photodetectors

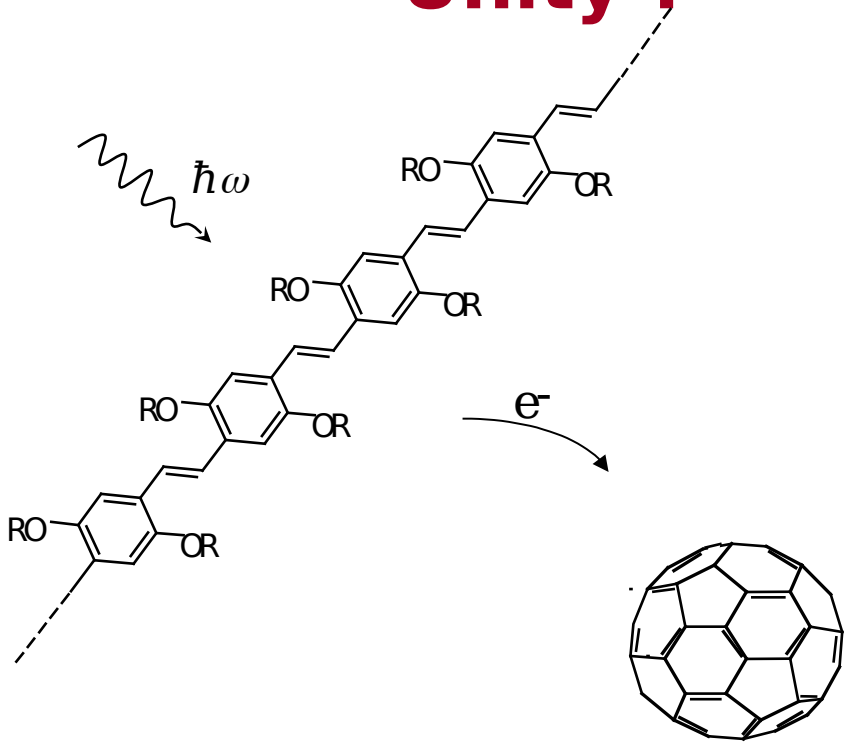
and

High Performance Biosensors

for

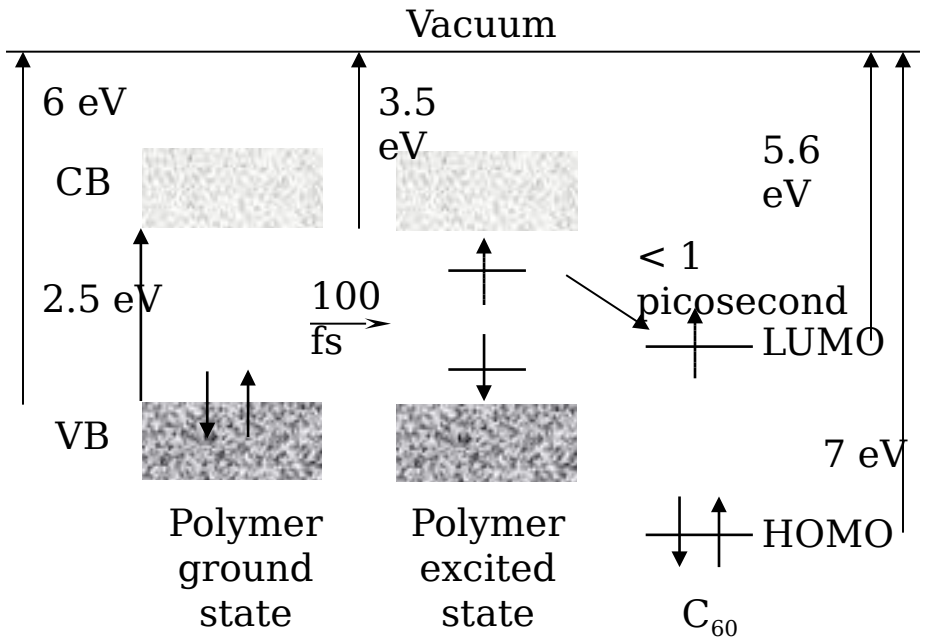
Fighting Bioterrorism

Ultrafast charge separation with quantum efficiency approaching Unity !



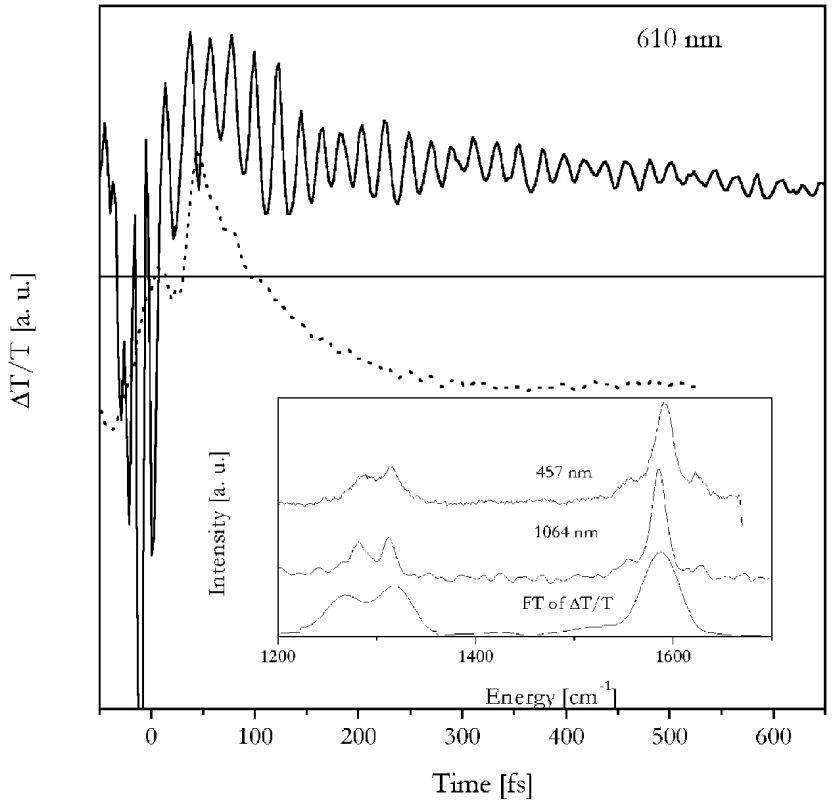
1992

Energy is conserved by exciting the hole in the continuum of the valence band



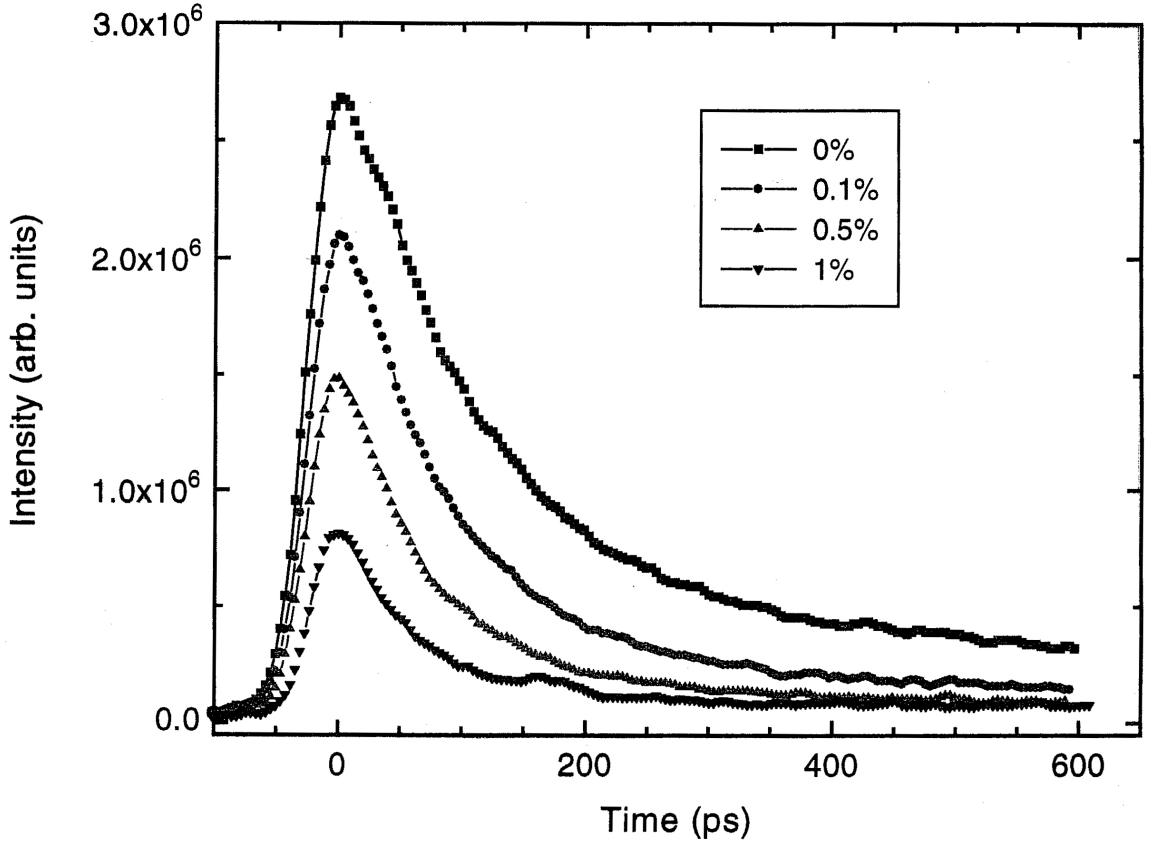
Ultrafast ---- 45 fs!

Brabec et al Chem Phys. Lett 340, 232 (2001)



- Time Resolved Photoluminescence

- Charge Separation Quenches the PL



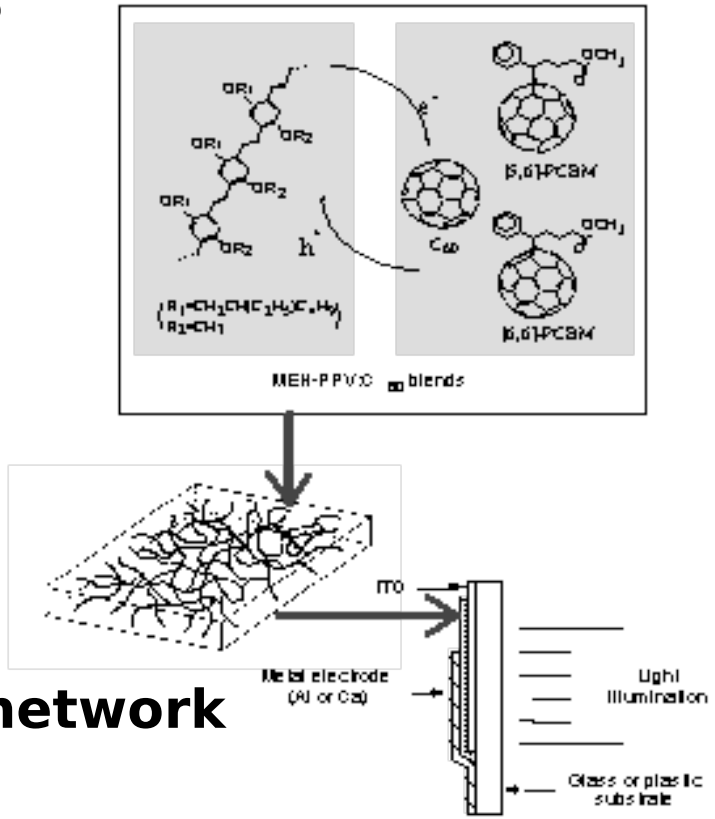
Solid films

Photodetectors and Photovoltaic Cells

- **Efficient Charge Separation ---**

but

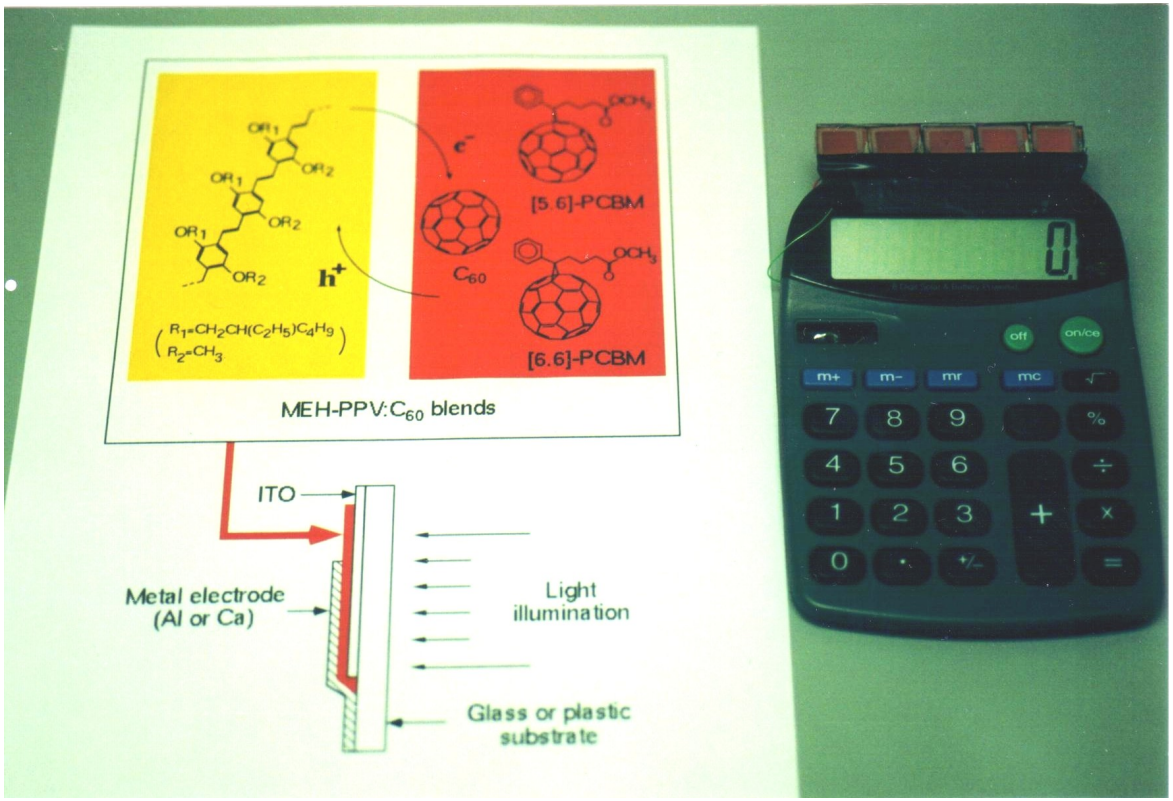
- **Can one collect the separated charges?**



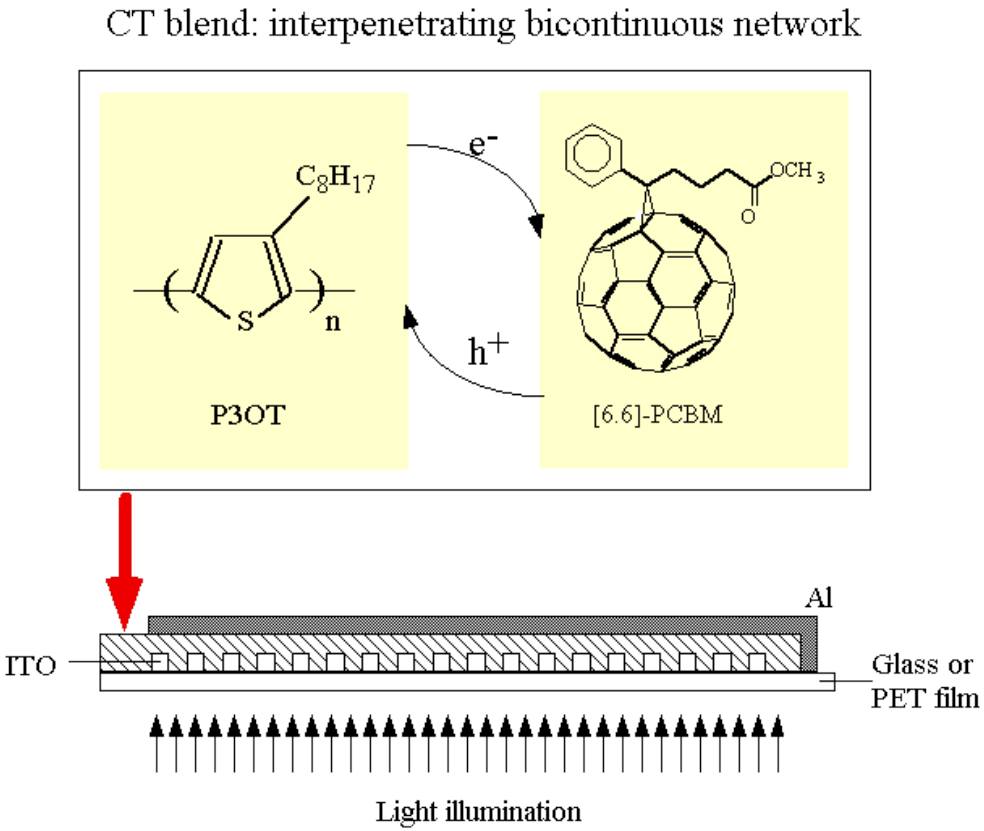
YES!

Interpenetrating network

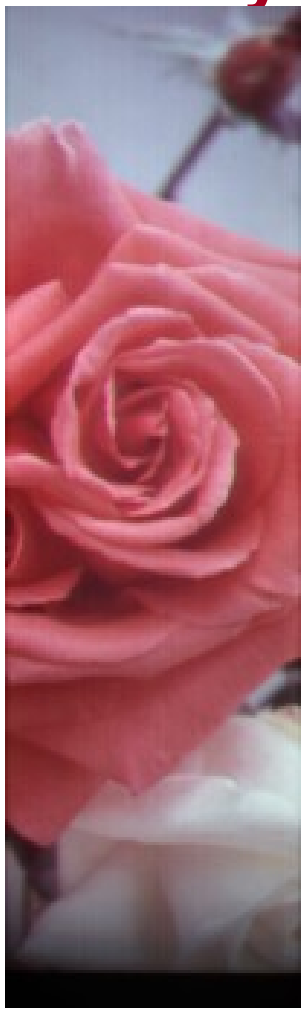
Photovoltaics with approx 3% efficiency



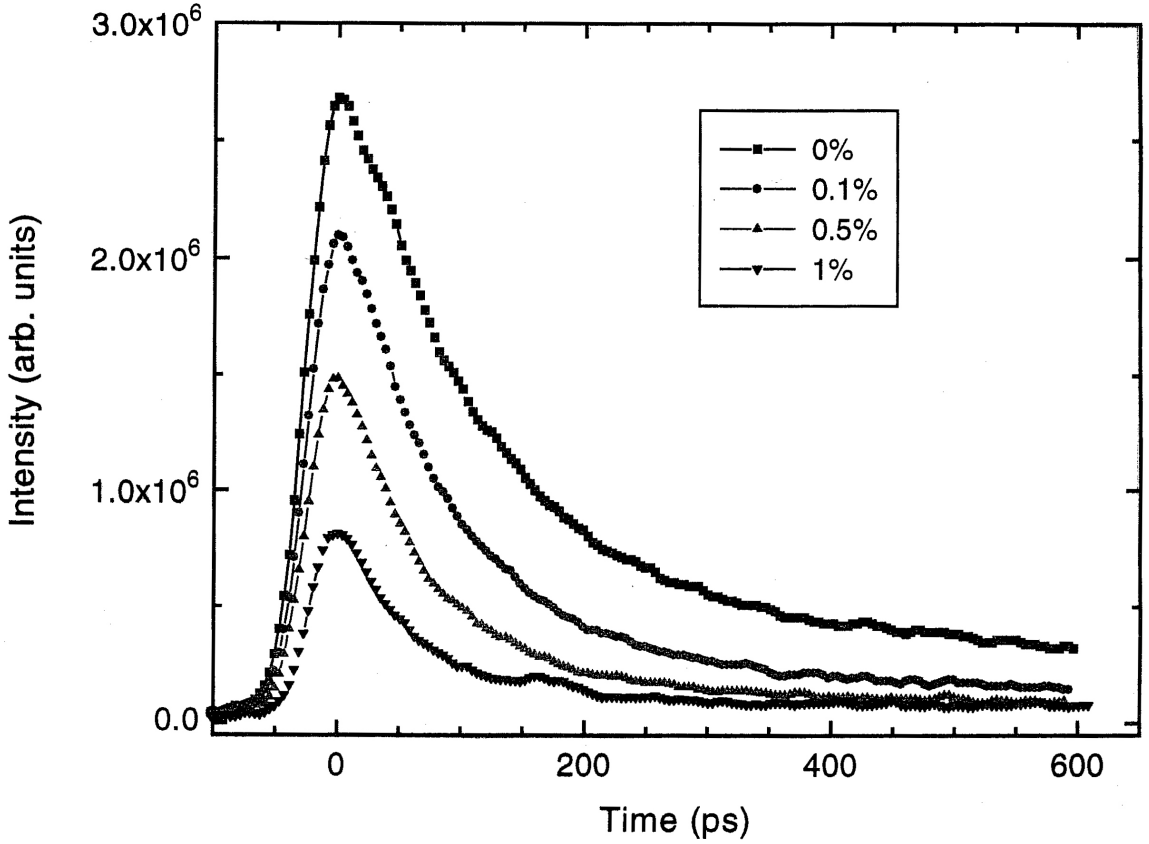
Diode arrays for digital imaging



Digital “Photography” with Polymer Diode Array



What about Biosensors??
Recall: “Superquenching” in solid films

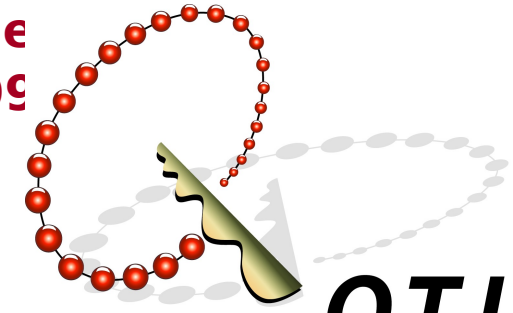


PHOTOINDUCED ELECTRON TRANSFER

- Quenches photoluminescence
- Requires close proximity of donor and acceptor species

Basis for a new class of biosensors

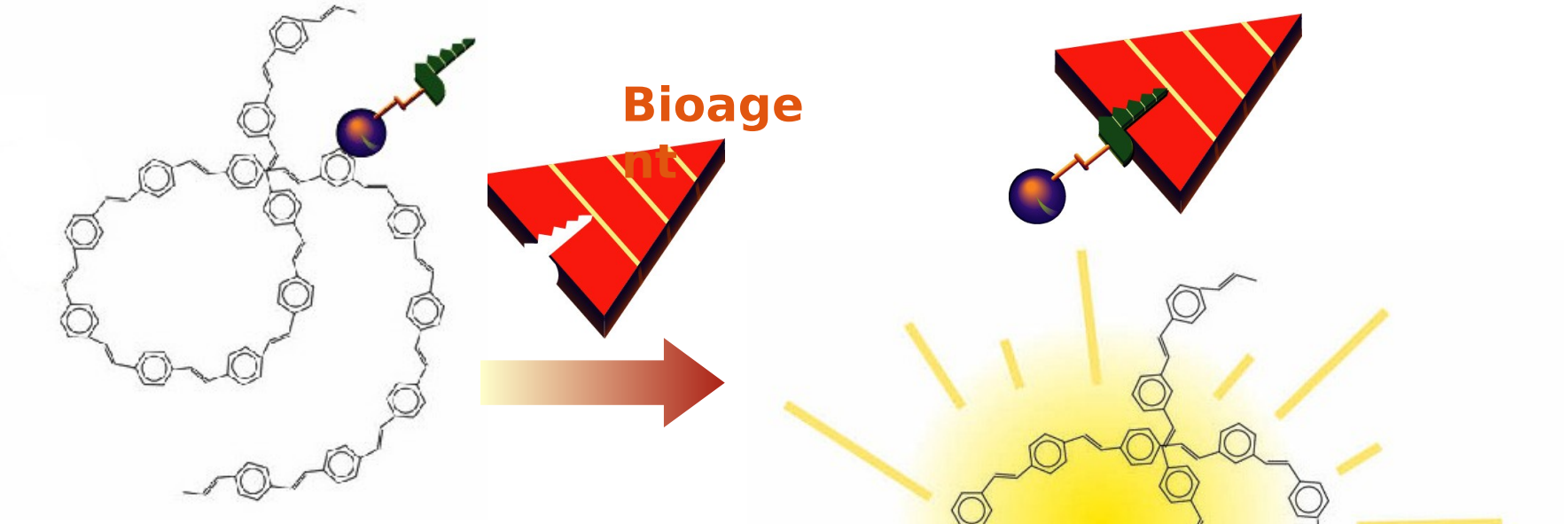
(Che A. 96, 12287, 199



QTL BIOSYSTEMS

QTLightspeed™: Molecular Light Bulb and a Switch

(QTL = Quencher – Tether – Ligand)



QTLightspeed was invented by McBranch, Whitten and colleagues at LANL in 1999.

Aqueous solution of conjugated polyelectrolyte and charged quencher such as methyl viologen

QTL Biosystems founded in 2000.

PNAS 1999, *96*, 12287

QTL Timeline: 1998-2001

1998-1999

Superquenching in aqueous solution and QTL discovered by Whitten, McBranch et al

Patent, first publication in PNAS

2000

QTL Biosystems begins operations

Superquenching extended to new polymers

Development of supported formats: eliminates nonspecific interactions

First competition assay developed

2001

Micro- and nanoparticle supported formats demonstrated

QTL sensing adapted to 96-well plate formats

Competition assays for proteins using peptide and protein-QTL's

Surface-activated superquenching in monomers and oligomers

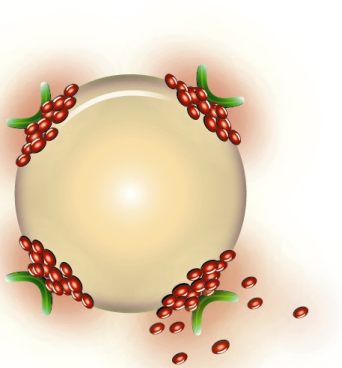
Better polymers: 100-400 luminescent repeat units per quencher

Platform using commercially-available microspheres + QTL polymers

The QTL Biosensor™

- QTL Biosystems has developed a prototype hand-held sensor for homogeneous immunoassays
- QTL Biosystems is developing a hand-held anthrax sensor <u>now</u>

Basis of Current QTL Bioassays

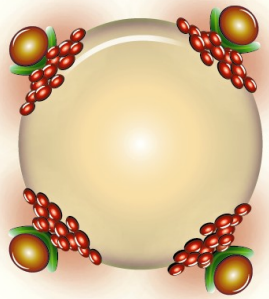


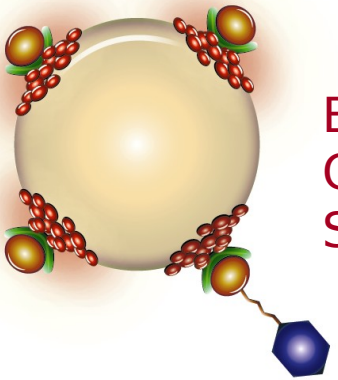
Bead coated with Fluorescent Polymer and Receptor which is specific to the analyte

Analyte

QTL Conjugate

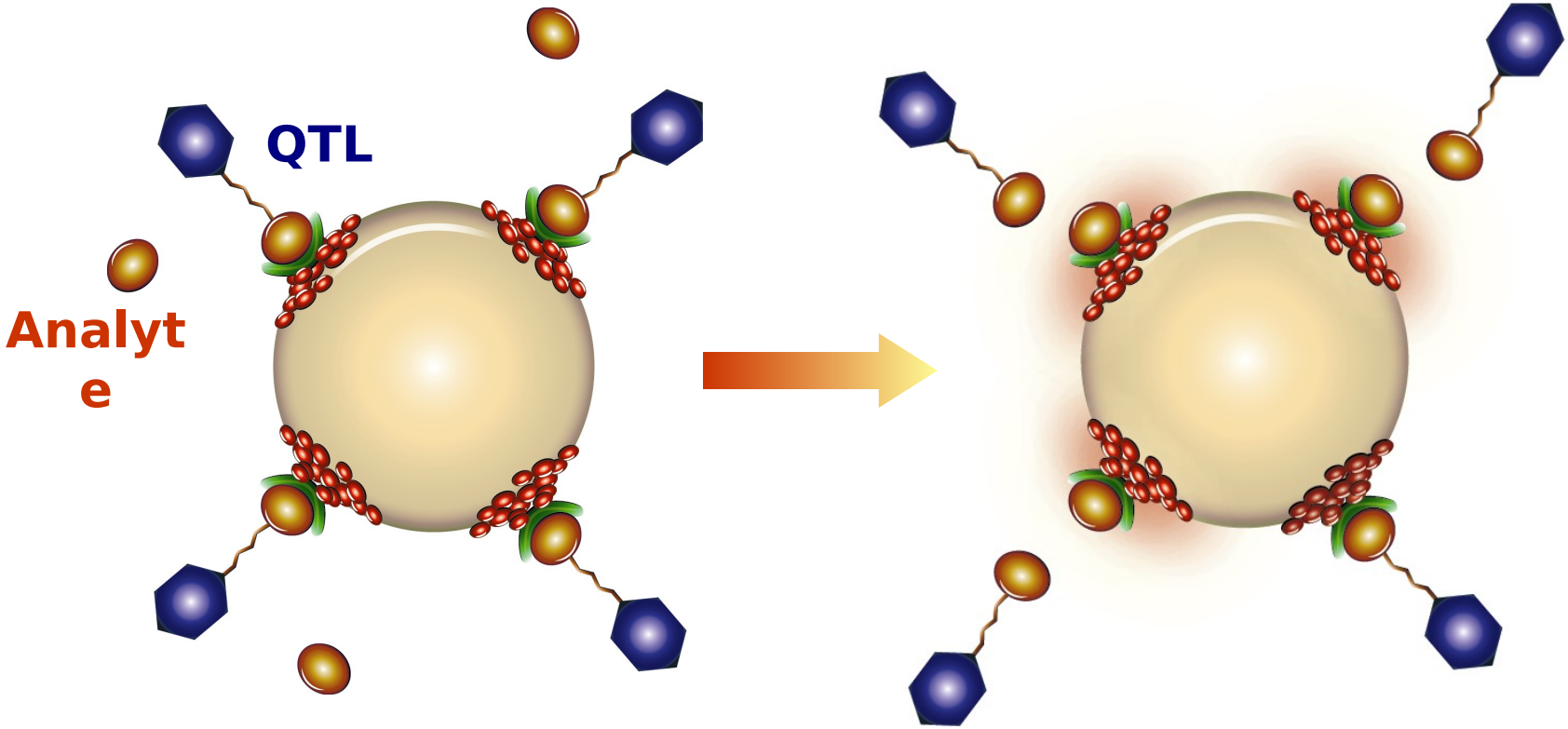
Binding of Analyte To Bead: No Quench





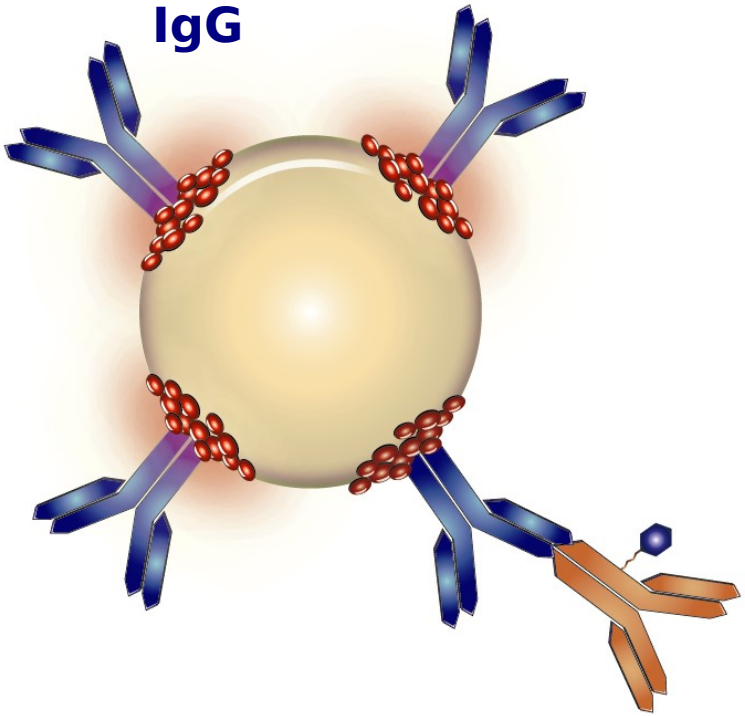
Binding of QTL Conjugate: Superquenching

Competition assay using QTLightspeed™:

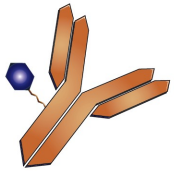


Antibody assay using QTLightspeed™:

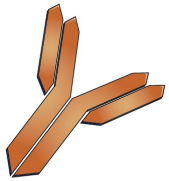
Capture Antibody: Biotinylated Monoclonal Mouse Anti-Rabbit IgG



QTL: Rabbit IgG-AF

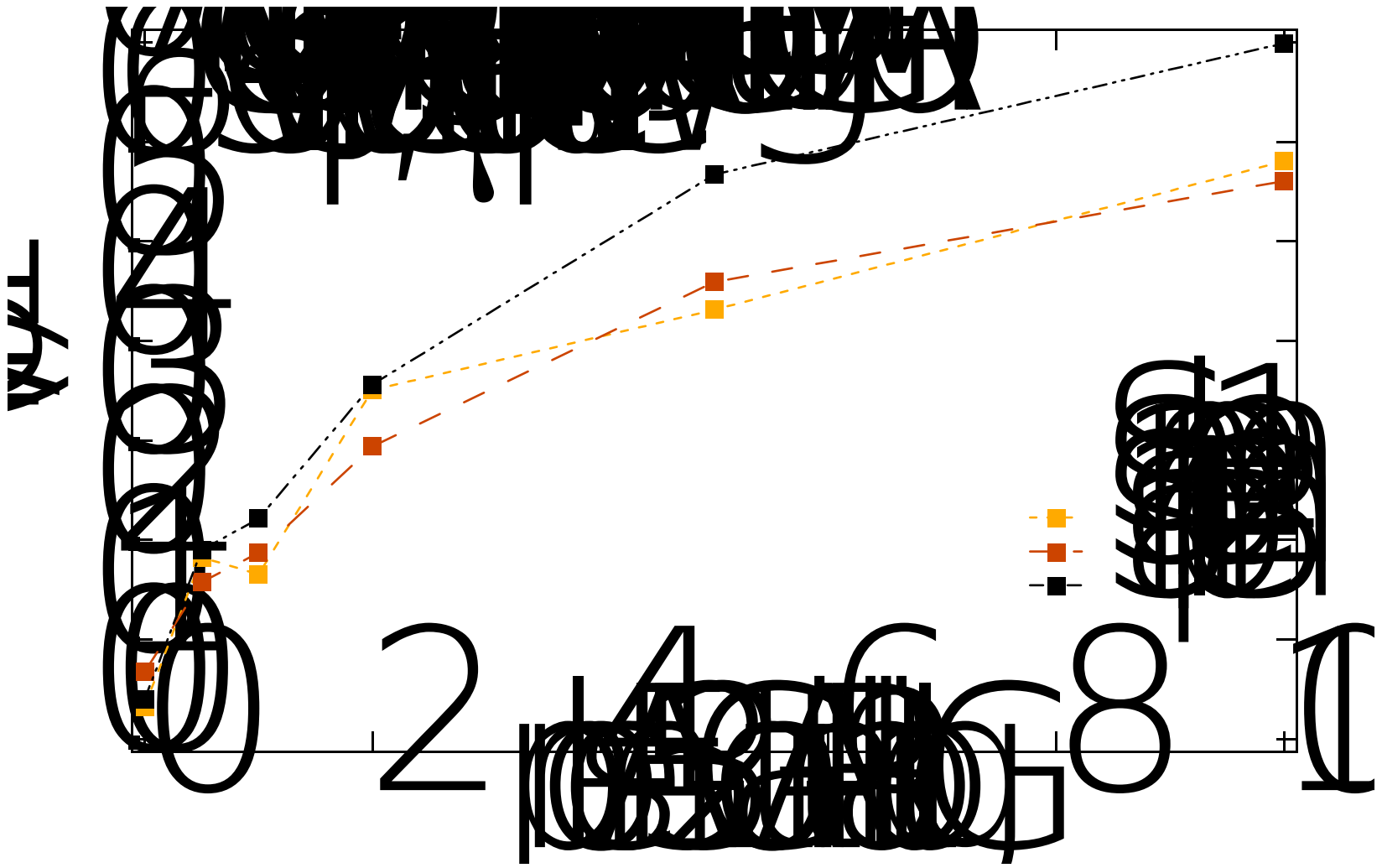


Analyte: Rabbit IgG



QTL BIOSYSTEMS

IgG assay: <100 fmolar sensitivity



Where is QTL Today?

- **Prototype Hand-held Detection System NOW**
  - **Now: Detection at 10-100 femtoMoles in seconds**
  - **Now: Detection of small molecules, and large proteins**
  - **Soon: Ability to detect whole organisms**

	Speed	Cost	Sensitivity	Detect Multiple Agents?
QTLightspeed™	<1 minute	Low	10 fMole	Yes, potential
PCR	1-4 hours	Medium	<1 fMole	No
ELISA	1-4 hours	High	50 fMole	No
Strip Test	15 minutes	Low	>1,000 fMole	No
Antibody Assays	30-60 minutes	High	10-100 fMole	No

QTL development supported by: DARPA DSO

Conclusion

Science is truly powerful !!!

One basic discovery, one good idea ----
Many Opportunities!!

Basic science can have impact on solving "real problems" --- such as Bioterrorism